CEMENT
AND
CEMENT MANUFACTURE
INCORPORATING "PORTLAND CEMENT"

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Effect of Temperature on Cement.*

THIS is a summary of the literature dealing with the effects of temperature upon the setting and hardening of cement, and a few original observations from the Building Research Station are included. Although it is not definitely stated, it was apparently hoped when the work of compilation was started that some relation between temperature and rates of setting and hardening would be revealed for the benefit of enquirers, but a reading of the pamphlet discloses nothing but a mass of discordant results which permit of no other conclusion than that already known, *viz.*, that the setting and hardening of cement are retarded by low temperatures and accelerated by high temperatures. The attempt to co-ordinate results was indeed doomed to failure from the start because of the absence of an agreed definition of setting time. The literature that has been summarised originated in all parts of the world, but the British idea of setting time is distinctly different from those adopted in America and in Continental countries. The British setting-time test merely indicates degrees of stiffening of a cement paste and is quite unrelated to the chemical and physical processes of setting, which alone are affected by temperature. Similarly, it was not to be expected that comparative results in the rate of hardening of cement would be shown by different testers, each with a different standard for consistency of mortar or concrete and period of mixing, and when further chaos is introduced by the use of different cements it will be realised that any satisfactory summary of the literature is impossible.

The manufacturer of rapid hardening cement has during the last few years had it forced upon his notice that even the 6 deg. F. range in temperature allowed by the British Standard Specification is too great to provide concordant strength results at early dates, and the tester who deals with many brands of cement has learned that one cement is more affected by slight differences of curing temperature than another.

The pamphlet is particularly disappointing from the cement manufacturer's standpoint because it does not provide any data of practical value and does not reveal any insight into the factors which govern this subject of fundamental importance. Those who have tested a number of different brands of cement know that the rate of setting of different cements varies considerably, and

* "Effect of Temperature on the Setting Times of Cements and on the Strength of Cements, Mortars and Concretes." Building Research Special Report No. 13. (London: H.M. Stationery Office. Price 1/- net. Pp. iv+38.)

with variations in this rate there are corresponding differences in the evolution of heat during setting and early hardening. Naturally, then, the action of frost or low temperature is opposed by the heat evolution in the cement itself, and some cements are therefore more susceptible to low temperatures than others and correspondingly less improved by warm curing.

A study of the effects of temperatures on the setting and hardening of cements must be accompanied by observations on the heat evolution of the particular cements during setting before conclusions of value can be drawn. An interesting line of research would be to determine the factors which encourage heat evolution during setting with the object of producing what might be called a "cold weather Portland cement." Although such a cement must not be unduly slow-setting, there is no virtue in a quick-setting cement for this particular purpose; the attainment of final set does not render the cement immune from attack by frost. It is the early-hardening properties which count in this connection, and where such early-hardening is due to heat evolution a "cold weather cement" is produced. Heat evolution during setting is associated with a high alumina content in Portland cements, for example, when the ratio of silica to alumina is less than 3, and does not necessarily follow the procedure of fine grinding and high-lime content which is usually adopted for the manufacture of rapid-hardening cement. Nor is it certain that the addition of extra gypsum, which is very useful in helping the early development of strength, is of value in causing heat evolution needed for resistance to frost.

When the effect of high temperature comes to be considered both setting and strength development are expedited, although when the temperature and curing conditions are such as to cause loss of water there is naturally a tendency in the opposite direction. It is curious that there is no mention in the report of the Deval Test, in which the submission of test-pieces to hot water at 180 deg. F. for a definite period was claimed to forecast the strength of the cement under normal temperature at later ages.

Some anomalies in the published tests are referred to in cases where curing at low temperatures of test-pieces immediately after moulding led to ultimately higher strengths than curing at normal temperatures, and, again, where heating immediately after moulding resulted in lower strength at later dates than curing at normal temperatures. The reason for these apparent exceptions to the general rule that heat improves strength and cold retards it is not elucidated in the report; they are probably due to the fact that the longer a cement-water mixture can be kept fluid so that solution and diffusion can take place the greater will be the strength, because more of the cement is chemically acted on by water. This seems to be the reason for the beneficial effect of gypsum additions on strength, *i.e.*, the cement-water mixture remains fluid for a longer time than it otherwise would. The same causes operate to produce the greater strength resulting from prolonged mixing of concrete.

If the composition of the cements had been available some useful conclusions might have been drawn, and if the Building Research Station would undertake tests on twenty different cements to relate temperature effects with chemical composition important results would be obtained.

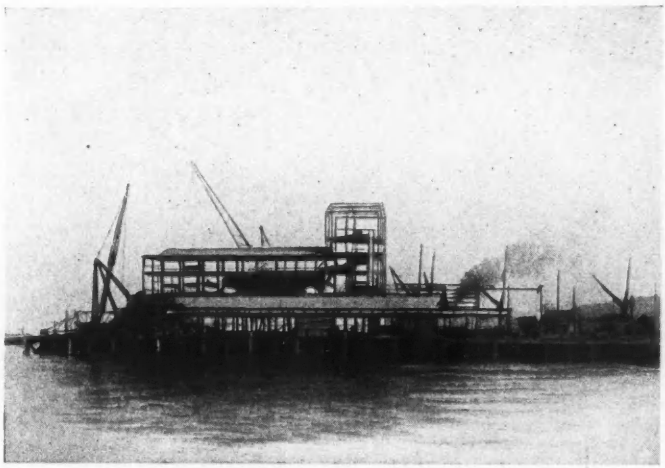
Johnson's Cement Works, Greenhithe.

(Continued from April number.)

Packing and Distribution.

THE packing plant is located on the river frontage, as the bulk of the cement produced is water-borne to its destination. The existing jetty has been enlarged, and upon it the packing building is situated. In addition to this jetty an extension is projected to lead farther out into the river to a large deep-water jetty available for ocean-going boats at all states of the tide.

The shore jetty has accommodation for vessels up to 800 tons burden to lie alongside and load, one on the upstream side and one on the downstream.



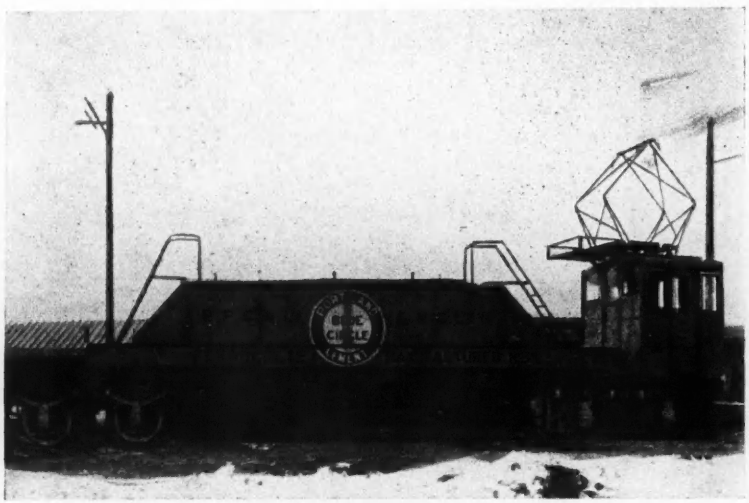
New Packing Plant and Reconstructed Jetty.

The deep-water jetty will accommodate a 10,000-ton vessel, the berth being dredged to give 26 ft. draught at lowest Spring tides. Vessels up to 1,600 tons can be handled inside the jetty.

Cement from the silos is discharged into 25-ton electrically propelled bulk wagons which enter the packing shed on one of two parallel lines, stopping over screw conveyors running below ground level between the rails. The bulk wagons have double hopper bottoms, in which screw conveyors, provided with slides at each end, run the full length of the wagon. These conveyors are driven by motors mounted on the front bogie. By opening the slides, rotating the screw conveyors and applying a little compressed air the contents of the wagons are delivered at a fixed rate into the screw conveyors below. These transport the cement to elevators, which raise it to the top level of the building. Here it passes through screens and conveyors, situated on the

centre bay of the building, over a series of storage bins which feed the cement packers, which are designed to deal with wooden casks, iron drums, and jute or paper sacks.

The packing building, which is 200 ft. long and 84 ft. wide, is divided into two sections each 100 ft. long. The river-end section is divided longitudinally into three bays, a central bay 24-ft. wide and two side bays 30-ft. wide. The central bay carries on its top story a row of six storage bins, each of 14-tons capacity, which feed six groups of four filling machines located on the centre line of the building. On these tables casks and drums are filled and packed and when weighed are removed and " headed "; the casks are " headed " by hand, and the drums in special heading machines. When this is com-



Bulk Cement Wagon.

pleted they pass to either of the side bays by gravity conveyors preparatory to loading.

At the far end of the building are bins of 30-tons capacity each delivering cement to four automatic packers, which fill and weigh cement into jute or paper bags. When filled, these can also be temporarily stored in the side bays or discharged direct, by means of a conveyor at each packer, on to flat trucks running on narrow-gauge lines along both sides of the packing building. The filled casks and drums can be similarly loaded on to these trucks. On each side of the building and running the full length of it are two semi-portal type level-luffing cranes having a capacity of 1½ tons at any radius up to 60 ft. These pick up the filled sacks, casks, or drums from the trucks and lower them into craft lying at either side of the jetty.

Two branches of the main railway line from the works also run on to the jetty, along each side of the building, and under the cranes, so that in emergency cement from the warehouses can be loaded into the various craft, while sacks, casks and other materials can be delivered to the packing plant or cement can be loaded for rail delivery.

The shore end of the building is divided into two equal bays on each side of the central lines on which the bulk cement-wagons rest. One bay serves as a storage for empties—casks, drums and sacks. The other bay is fitted with machines for making the rolled-steel drums and heads.

The packing plant is arranged for a normal output of 100 tons per hour, and on emergency this can be increased substantially by supplies coming from the packing plant in the warehouses.

Deep Water Jetty.

The deep-water jetty now projected will be 380 ft. long and 40 ft. wide. It will be connected at its downstream end to the packing-plant jetty by curved arms leading to the two sides of the packing place. The jetty will be equipped with three portal cranes, each of a lifting capacity of 1½ tons, which can serve the full length of the jetty. These cranes will span the full width of the jetty and load on either side of it, picking up from the four-rail track which will run beneath them.

Cooperage.

All the casks required for the export trade are made in the fully-equipped cooperage situated at the rear of the kiln building. Large supplies of staves are stored for seasoning purposes in the cooperage yard, which is connected by railway lines with the jetty. The cooperage has an output of 10,000 casks per week; the finished casks are forwarded by rail to the storage bay in the packing plant and also to the warehouses.

Sack Store.

The sack store is 140 ft. long by 82 ft. wide, divided into five bays so that different types of sacks can be stored separately. This building has a storage capacity of 500,000 sacks. Along the front of the building on a separate siding the sacks are loaded and unloaded under cover into railway wagons, the floor of the building being raised to the level of the truck floors to facilitate loading.

Buildings.

The new main offices for the Works occupy a building about 200 ft. long and 30 ft. wide. It contains an up-to-date slurry laboratory equipped with all the necessary appliances for testing slurry, cement, coal, flue gases, and the other many details essential to the manufacture of the modern cements now being produced. Adjoining the laboratory is the garage. The next portion of the building comprises the general offices, to be followed by a large mess room and recreation room for the men. The whole of the building is

equipped with central heating. The old general stores buildings have been enlarged and modernised, and adjoining these is a well-equipped first-aid room.

Fitting and Repair Shops.

The fitting shop has been extended, and is equipped with all the necessary machine tools for undertaking ordinary running repairs to the plant, and in addition there are carpenters', electricians', and electric welding shops and forge.

Railway Lines and Roads.

The whole of the Works is equipped with an extensive network of 4 ft. 8½-in.-gauge track, capable of carrying the heaviest traffic carried on the main lines of the country. This system is directly connected to the Southern Railway by a private siding and feeds every necessary building throughout the Works.

In addition to the railway, new reinforced concrete roads run through the Works and connect the loading bay at the warehouses to the main road. These roads, which are all laid on the same level, allow easy transport for all forms of road traffic.

POWER SUPPLY.

When considering the problem of the power supply to a large cement works, the first essential is the absolute reliability of the source of power chosen. The production of electric power, whether publicly or privately generated, has now reached a standard of efficiency which fulfils this requirement, and, since it presents many other advantages in the direction of cheapness and adaptability, it has been selected in this instance. The system installed is 3-phase 50-cycles, at alternative pressures of 3,000 and 500 volts.

Power is supplied from the adjacent Kent Cement Works, owned by an allied Company, where two turbo-alternator sets each of 4,000 KW capacity, and one set of 6,000 KW capacity, generate energy at 3,000 volts, at which pressure it is transmitted by three parallel feeders, two being of 3 × 0.4 sq. in. cross section, and the third of 3 × 0.2 sq. in. cross section. The cables are paper-insulated, lead-sheathed, and double-steel-tape armoured laid direct in the ground. The run is approximately 1,100 yards long. An interesting problem encountered en route was the passage of the Southern Railway Co.'s embankment, through the base of which the cables were pulled through holes made by a system of thrust boring and lined with 4 in. int. diameter fibre tubes by means of a " Magnall Irving " hydraulic thrust boring machine. The length of the " shoot " was 80 ft.

At the receiving end the feeders terminate in a 3-panel truck-type switchboard situated in a small annexe to the main substation. Each panel is provided with the usual protective features, and the bus-bars are directly connected to the main feeder-board situated in the substation proper, from which point distribution may be said to commence.

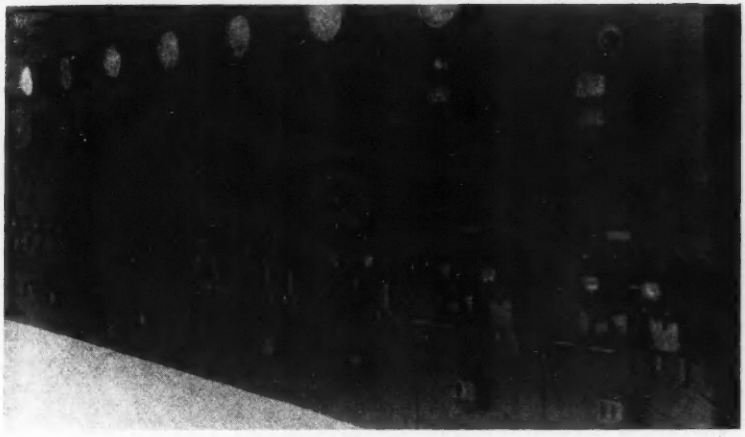
Power Distribution.

Before going further into the details of the distribution system, it may be of advantage to furnish a brief resumé of the amounts of power to be dealt with

in order that the method by which these details have been worked out may be appreciated.

The aggregate horse-power connected totals 10,200, and in addition 150 KW is provided for lighting services. To allow for future extensions a maximum capacity of 8,000 KW has been provided. When fully loaded an overall power factor of 0.9 lagging will be obtained on the system by means of synchronous motors having a total capacity of 3,660 K.V.A. at unity power factor. Also with a view to further extensions of the generating plant, all apparatus down to and including small fuses in the lighting main has been designed with a rupturing capacity of 100,000 K.V.A. on short circuit.

From the main substation power is distributed to six Works' substations by means of radial feeders at a pressure of 3,000 volts throughout. All trans-



Main Substation Switchboard.

mission is by 3-core paper-insulated lead-covered and armoured cable laid direct in the ground and suitably protected by means of concrete covers. The rating of all cables is such that they will economically carry 50 per cent. in excess of their present maximum rated load. The total horse-power connected at each of the six Works' substations is as follows:

Chalk quarry	190 H.P.
Clay washmill	420 H.P.
Washmills, including pumping plant	2,400 H.P.
Kilns, coal mills, and auxiliaries	1,550 H.P.
Grinding mill, conveyors, and auxiliaries	5,040 H.P.
Jetty and packing plant	590 H.P.

In the three instances, where continuity of supply is essential, duplicate

feeders have been provided, each capable of dealing singly, in case of emergency, with a sufficient proportion of the load to maintain production.

For the control of this supply there is installed in the main substation a 14-panel switchboard of the ironclad draw-out truck type. The board comprises one 2,000-ampere non-automatic isolating switchpanel, and one main summation panel for the metering of the entire Works' load, the remaining 12 panels controlling the outgoing feeders to the various Works' substations. Each panel is provided with overload, no-volt, and sensitive earth-leakage protection.

At the receiving end similar panels are installed for the control of the incoming feeders, step-down transformers, and of any motors operating at 3,000 volts. In general, the switchgear is housed in a small annexe adjacent to the plant in order to reduce the runs of cable as far as possible. At the washmills eleven such panels are required, and ten at the kiln substation, while at other points a single panel suffices.

Mention may be made of substations installed both at the quarry and the clay pit sites. These are designed for outdoor operation entirely, all switchgear, transformers, etc., being mounted on a concrete slab and fenced round with wired concrete posts. No excavation is required, and building costs are reduced to a minimum.

At each of these substations local power distribution to the section of the Works concerned is controlled. Motors of 100 H.P. and upwards are connected direct to the 3,000-volt supply, as it has been found from experience that E.H.T. motors sufficiently robust for the arduous conditions prevailing can be economically manufactured down to this output; their use eliminates transformation losses (which may be considerable over long periods of continuous running), and reduces cable costs materially. All other motors operate at 500 volts, and transformers are installed to provide this supply. A total of five units of 750 K.V.A. capacity each, and two of 500 K.V.A. each, is installed. They are of the self-cooled oil-immersed core type suitable for outdoor operation.

The L.T. side of each transformer is controlled by unit pillar type ironclad switchgear. Each panel has a carrying capacity of 1,000 amperes and a rupturing capacity of 30,000 K.V.A. on short circuit, and on each unit complete protective and metering arrangements are installed.

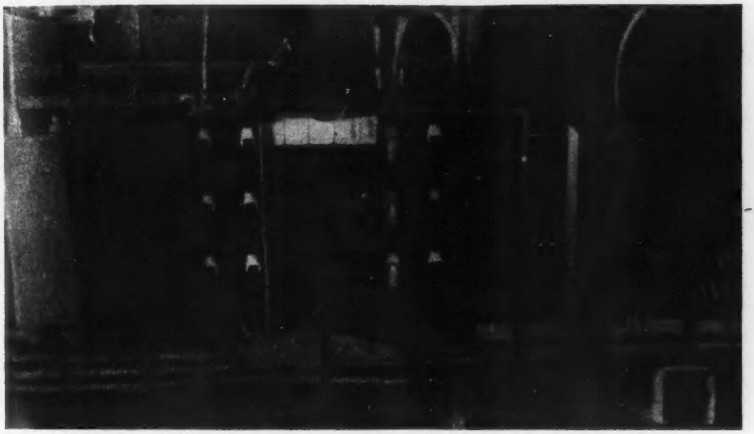
In general, the low-tension distribution may be divided into two sections. First, the main and branch feeder cables terminating in the fuse panels about to be described; and, second, from these panels to the individual motors.

Dealing first with the primary distribution, which is carried out by 3-core cable, an endeavour has been made to preserve continuity of supply wherever possible by the use of a ring main, the ring being split at mid-point by a suitable link-box similar in general form to the larger fuse panels. At suitable points as near as possible to the various load centres the ring is tapped by fused section-boxes having two or three branches ranging from 100 to 300 amperes capacity per branch. These boxes, which have been especially developed to meet the peculiar conditions prevailing, are of dust and

weather-proof sheet-steel construction and have a rupturing capacity of 25,000 K.V.A.

All motors above 25 H.P. are fed by distributors direct from these boxes, but for smaller machines a further subdivision is made. In such cases the distributor from the fused section-box is fed into a distribution box of similar construction, but having from four to ten branch circuits ranging from 25 to 75 amperes capacity. Like the larger boxes, the fuses have a rupturing capacity of 25,000 K.V.A. In all cases 50 per cent. of spare ways have been provided on each board for future requirements, the aim of the whole installation being to provide a system of maximum flexibility and to be capable of considerable extension without disturbance to existing circuits.

Turning next to the secondary distribution from the fuse panels to the motors, this is carried out in 3-core V.I.R.S.W.A. cable, this type of cable



Low Tension Distribution Panels.

having been found the most suitable for the severe handling it may on occasion receive while at the same time being easy to instal and providing a continuous earth bond. The starters are of the ironclad oil-break pillar-type, in general mounted individually. Where squirrel motors are installed the greatest possible use has been made of the star-delta pattern in conjunction with high-torque motors. This type of starter has simple mechanism, a minimum of internal wiring, and is eminently suitable for unskilled operation. It has been found that the 70 per cent. starting torque available with this combination is sufficient to break the great majority of drives and is the cheapest proposition. For other drives of a special nature auto-transformer, direct, or combined rotor starters are used. No-volt and overload protection is provided, the latter taking the form of a thermally-controlled trip,

calibrated to open circuit as soon as the safe heating limit of the motor windings has been reached.

The motors installed, numbering over 150, range from six 750 H.P. unity power factor synchronous induction motors to a 1/6 H.P. induction motor driving a timing device. All motors are fitted with ball or roller bearings, special precautions having been taken to seal effectively the housings of these against dust.

The larger motors of 100 H.P. upwards are of the standard induction type calling for no particular comment. The range of smaller motors of 5 to 50 H.P. capacity which forms the great majority of those installed, and which in many instances drive units vital to production, embody several features tending towards reliability in operation and ease of maintenance. The enclosure is drip-proof, so arranged, however, that ample ventilation and an output equal to that of the ordinary enclosed ventilated machine are obtained. This form of enclosure has been found in practice to be of particular service in situations, frequently met with in a cement works, where large accumulations of dust occur. The design of the motor is such that, taking, for instance, a standard 15 H.P. frame, a man of average ability and his mate may dismantle the machine, withdraw the rotor and insert a new one in half-an-hour or less. Squirrel-cage machines are generally installed on account of their inherently robust and simple construction and for the saving in cost effected. Where, however, the starting torque is likely to be heavy, standard slipring machines are employed. Standardisation of output and speeds has been aimed at, and apart from a few special drives the range of frame sizes in use has been reduced to eight, all motors of the same speed and output being fully interchangeable both mechanically and electrically.

While the great majority of drives installed are adequately catered for by these standard motors, there are several instances where special requirements have to be met. The synchronous motors driving the cement grinding mills have already been mentioned, these units being particularly suitable for power-factor correction both on account of the steady nature of the load and the high proportion of the total load which they form. The motors are direct-coupled to the mill countershafts and run at 158 R.P.M.

For driving the kilns, where a speed ratio of 3 : 1 is necessary, special 3-phase commutator motors are employed. For the large kilns two motors each of 150/47 H.P. 650/225 R.P.M. are installed, and for the smaller original kilns two motors each of 65/22.5 H.P. 710/245 R.P.M. These motors are totally enclosed, with closed-circuit water-cooled forced ventilation, and are all arranged for remote control from the firing platform.

The main coal-firing fans present another variable-speed problem, and, since in the case of the large kilns the range was somewhat outside the present standards for A.C. commutator machines, it was decided to use direct-current motors with shunt-speed regulation. Three such motors were installed, one of

them being a stand-by unit, each 80/45 B.H.P. 1,500/1,150 R.P.M. with automatic contactor starters.

Lighting.

The lighting installation presents one or two points of interest. It was decided to minimise the risk of interruption by tapping direct off the main 3,000-volt bus-bars and running an E.H.T. ring main round the Works. Approximately 2,300 yards of 3-core cable were laid direct in the ground, arranged to serve every part of the Works. The outgoing and incoming ends of the ring are controlled at a sheet-steel kiosk situated in the Works' substation and equipped with fuses and links for the control of the ring. Metering apparatus is also provided, together with an oil switch for isolation from the main bus-bars. Full interlocking arrangements to ensure the safety of operators are provided.

The ring is tapped at seven points, which form convenient distribution centres, by means of smaller kiosks of generally similar construction. The incoming and outgoing ends of the ring are controlled by links, and the tap to the step-down transformers by links and fuses. The kiosks are weather-proof, and when possible they are installed out-of-doors to minimise building costs.

For the supply of power to the lighting circuits one or more step-down transformers are used at each feeding point. Each transformer, which is of the oil-immersed core type, has a capacity of 15 K.V.A., 3-phase, 3,000/110 volts.

The L.T. lighting circuits are in heavy screwed galvanised conduit, the feeds being balanced out on the three phases of the supply. The system of installation is such that the effects of the dusty atmosphere are countered as far as possible. The problem of dust also arose when making the choice of fittings. For general interior and exterior lighting the number of points has been reduced as far as possible, units up to 300 watts per lamp being installed. A special form of reflector with burnished stainless-steel surfaces has been fitted, and it has been found that this type gives the desired even illumination over a wide area combined with a high maintained efficiency for a long period. For secondary lighting of stairs, passage ways, etc., no fitting is used, the average type of enamelled reflector merely acting as a dust-trap in most instances.

Mention may be made of a floodlighting scheme embodying two banks, each of four 300-watt projector lanterns. These illuminate a sign 106 ft. long by 7 ft. deep with 6 ft. lettering placed on the top of the cement silos. In clear weather the lettering is legible half-a-mile distant, and the silos themselves are visible two to three miles away.

Electric Traction.

A system of electric traction has been installed between the silos and the packing plant. The length of track and frequency of the service made this an

economical proposition and the considerable stand-by losses inseparable from a steam locomotive are eliminated. A total of 750 yards of single track together with two sidings at each end have been electrified, the system being 250-volts direct-current with single overhead trolley wire and earthed return rail. Three sets of bogies are provided, each set comprising one 4-wheel driving bogie and one 4-wheel trailing bogie. Slung between these is the cement container of 25 tons net capacity.

Each driving bogie has mounted upon it two 25-H.P. motors (one geared to each driving axle), the cab with all necessary control gear, and a 12-H.P. motor and gear for the cement agitator drive. Mounted on the cab roof is a spring-controlled pantograph collector. The bogie is designed for a speed of 7 m.p.h. on the level, fully loaded, and as at present arranged two bogies will be in continuous operation, ten minutes being allowed at each end of the track for loading and emptying respectively and a further ten minutes for the double journey, making an allowance of thirty minutes for each complete cycle of operations.

Two motor generator sets, one being a stand-by, provide the 250-volt D.C. supply for the traction and main firing-fan motors previously referred to.

Notes from Abroad.

Moroccan Cement Trade.

According to a report from Consul-General Gerth van Wijk, of Tangier, the demand for cement in Morocco has considerably increased owing to growing activity in the building trade there, notably at Casablanca, Rabat, and Fez. There is also good reason to expect an increase in the consumption of cement in connection with the construction of the Oudjda-Fez and Oudjda-Bou Arfa railway and projected harbour improvements. The cement requirements are partly supplied by the home industry. The Societe des Chaux et Ciments, of Casablanca, supplies mainly in the French zone. The principal competitor of the works is France, but Belgian, Italian and Central European competition is also making itself felt to an increasing extent. The present price of cement at Casablanca amounts to from Frs. 260 to 290 (41s. 6d. to 46s. 6d.) according to quality.

Proposed Cement Works in Brazil.

German newspapers report that a German-Brazilian firm has applied to the Brazilian Government for a concession to erect a cement plant at Barnacena, in the State of Minas Geraes.

New German Cement Factory.

The Almetal Zement & Kalk Werke, g.m.b.H., in the Buren area, is proposing to erect a plant with an output of 30,000 tons of cement per annum.

New Oxfordshire Cement Factory.

WE are now able to give further particulars of the new plant of the Chinnor Cement and Lime Company, situated at the foot of the Chiltern Hills, near Chinnor, Oxfordshire, which was briefly dealt with in our December, 1928, number. The works are owned by Mr. Wm. E. Benton and Mr. Norman M. Benton. The general design, arrangement, and erection of the plant were under the supervision of their works manager, Mr. A. A. Short, M.I.Mech.E. The contract for the plant was carried out by Messrs. Edgar Allen & Co., Ltd., of Sheffield.

The new works, a general view of which is shown in Fig. 1, replace a smaller plant started by Mr. Benton in 1921, consisting of a battery of improved-type chamber kilns, and which included Edgar Allen machinery for the preparation of the raw materials and for the grinding of the cement clinker. The new cement works has been erected alongside, incorporating many up-to-date features, and

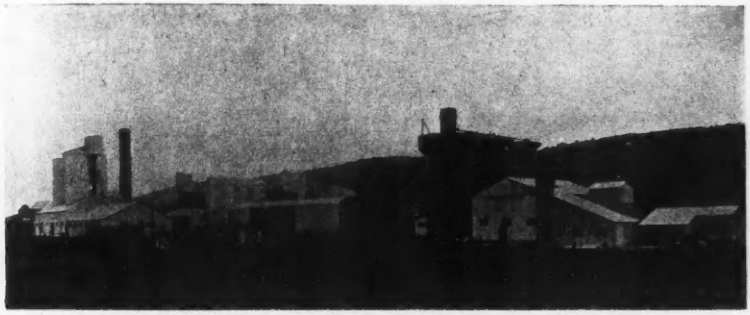


Fig. 1.—General View.

including a rotary kiln for the production of 40,000 tons of cement clinker per annum. Provision is made for the erection of a second rotary kiln alongside the first kiln, and all the auxiliaries such as elevators, conveyors, etc., are large enough to handle the increased product when the second unit is installed.

The raw materials available include the upper and middle chalk and marl, varying in content of calcium carbonate from 98 to 42 per cent., and there are ample quantities of these raw materials for over 100 years' production. At present only the middle chalk and marl are being used, these materials being adjacent to the works and therefore the most accessible.

Overburden to be removed from the top of the chalk is very slight, at some parts being only about 6 in. thick, and after loading into one-cubic-yard skips it is power hauled and tipped in an old working. A Ruston caterpillar-crane type steam navvy is used for digging the chalk, which is of a soft nature and easy to handle. The digger-bucket delivers direct into side-tipping wagons of 1 cu. yd. capacity running on a 2-ft. gauge railway with rope haulage. A

double track is provided with an endless steel rope having an approximate range of 1,000 ft. The haulage gear is driven by an electric motor; one track is used for hauling full wagons to the washmill and the other for returning empties. The digger works alongside the incoming wagons and parallel with the track, there being a movable filling-hopper which advances or retires with the digger and arranged so that the bucket discharges direct into the stationary wagon under the hopper without the necessity of operating levers and doors; this is a great convenience in wet weather when the material is sticky. The wagons are each fitted with automatic catches for engaging or disengaging with the rope, so that the amount of labour required for operating the haulage gear is reduced to a minimum. This saving of labour shows itself throughout the works; the only labour required for skilled maintenance to keep the whole of the

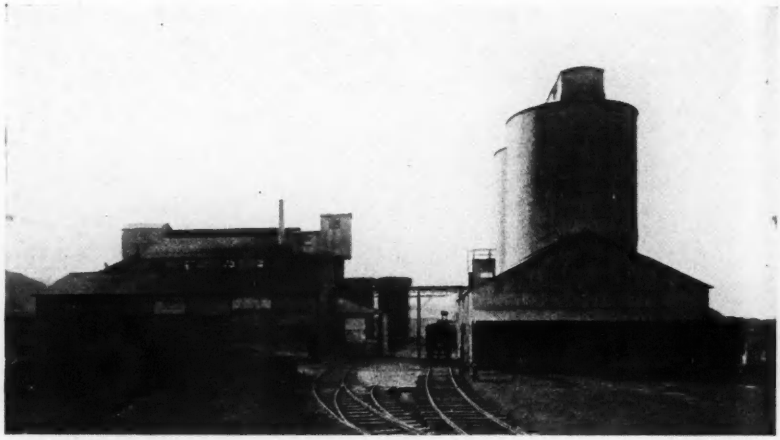


Fig. 2.

mechanical and electrical plant in efficient working order amounts to two engineers and a blacksmith.

The chalk wagons are tipped by hand into a 20-ft. diameter washmill. A hand-quarrying gang is employed to provide the small amount of marl or high-calcium material required to correct the chemical composition of the wash.

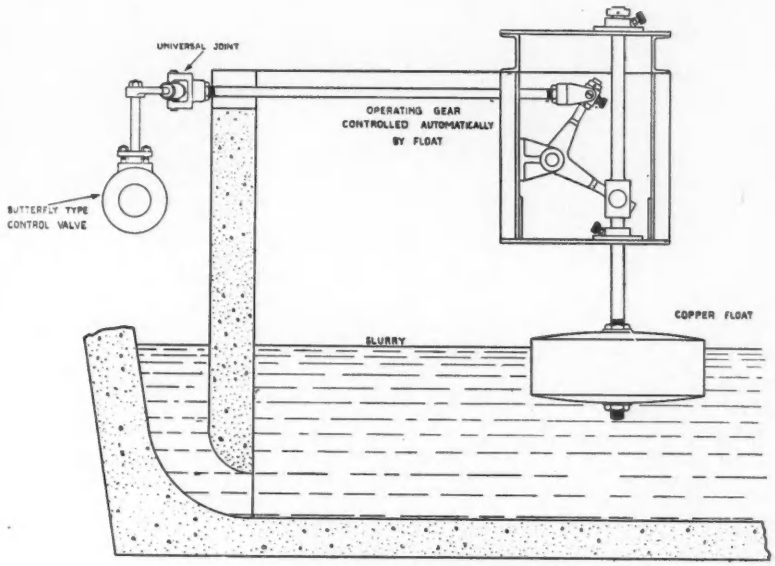
The slurry leaving the washmill contains approximately 40 per cent. of water. The washmill is large enough to provide slurry for two kilns, so that no addition will be required to this department when the second kiln is put down. The slurry gravitates from the washmill to a vertical steel-cased bucket-elevator, which discharges at sufficient height to feed a battery of three Allen slurry separators. These separators take out of the slurry any coarse particles that have not been sufficiently reduced in the washmill, and these return by gravity for further washing.

The finished slurry from the separators flows through a series of wooden

launders to the suction pit of the slurry pumps, the fineness being such that less than 5 per cent. is retained on the 180-mesh sieve. The finished slurry is pumped to storage tanks by a set of three-throw plunger pumps 8¾ in. diameter by 16 in. stroke. Three storage tanks are provided in mild steel, 24 ft. diameter by 48 ft. total height, the bottom cones being tapered to a 6-in. diameter outlet and connected together by pipes and valves so that the slurry contained in any tank can be used for the kiln feed as desired. The tanks are at ground level, with an access ladder to the top for operating the air supply used for agitating the slurry in the tanks.

For this purpose a two-cylinder air-compressor manufactured by Messrs. Broom & Wade, Ltd., of High Wycombe, supplies the necessary air pressure. Inside their periphery the tanks have a series of 1-in. diameter pipes with special nozzles leading down to the cone portion, and when it is required to agitate the slurry to prevent the solids settling out the compressed air is turned on; the escaping air passing up through the mass causes ample agitation to keep the slurry in liquid form so that it will run by gravity to a further set of pumps providing the feed to the kiln. Each tank holds about 650 tons of slurry, and as one at least is always kept full there is sufficient storage to keep the kiln running over week-ends and at such times when unforeseen stoppages might be enforced.

A special feature in connection with the suction pit of the kiln-feed pumps



BUTTERFLY FLOAT CONTROLLED VALVE
FOR SLURRY MIXER.

Fig. 3.

is an arrangement of automatic float valve which controls the flow of the slurry from the storage tanks and prevents flooding of the open pit due to the head of slurry in the storage tanks. The float valve is of Alley & Maclellan's make, and will shut off the supply of slurry automatically whenever the pumps feeding the kiln are stopped.

The water supply to the works is obtained from three wells situated near the compressor house. The wells are 180 ft. deep, and have air-lift pumps which lift the water to a large storage tank which supplies the whole of the works, including the washmill and water-cooling system on the kiln bearings.

The rotary kiln is of combined kiln and cooler type, carried on five cast-steel tyres of substantial dimensions with supporting rollers and beds. Driving gear

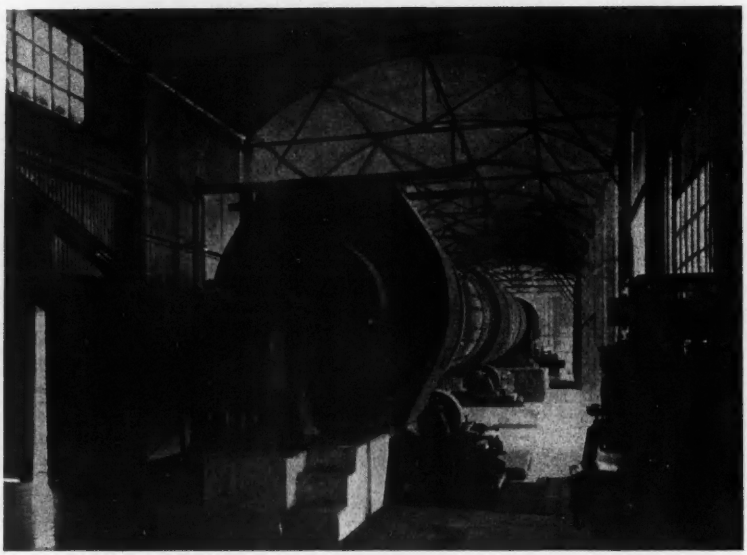


Fig. 4.—Rotary Kiln.

is of cast steel, and is fitted with a countershaft and driving pulley for belt drive from a variable-speed motor. The kiln is 7 ft. 6 in. internal diameter by 185 ft. total length, and has an enlarged burning zone 9 ft. diameter. The kiln is lined with firebrick, and has slurry lifters at the inlet end. The last 20 ft. at the outlet end is fitted with lifters which cause the hot clinker to fall through the cool air, required for combustion, which is passing up the kiln, preheating the air and cooling the clinker at the same time. Another advantage of this type of combined kiln and cooler is that the foundations are much less in height and the kiln is more accessible than in the case where the cooler is separate and placed underneath the kiln.

The slurry is fed automatically to the kiln-feed pipe by a rotating feeder

driven from the kiln, so that the speed varies in the same ratio as the revolutions of the kiln. A constant head of slurry in the feed tank also ensures an even flow. The kiln gases are withdrawn by an induced-draught fan delivering into a brick chimney, and the kiln dust-chamber is provided with a chain-scraper conveyor which continuously removes the dust deposited by the gases on their passage from the kiln to the fan. The conveyor delivers the dust into the suction pit of the kiln slurry pumps, and automatically returns to the kiln for burning.

The kiln is fired by powdered coal. (Fig. 4 is a photograph from the firing end.) Temperature of flue gases and draught measurement are diagrammatically registered on the burners' platform, and all controls are readily accessible to the burners' hand. The coal is dried before grinding in an Allen double-shell dryer, the final moisture not exceeding 1 per cent. From the dryer the coal is fed to a " Stag " combination tube mill 5 ft. diameter by 28 ft. long, driven by a 200-h.p. slow-running motor direct coupled to the mill countershaft and driving through one set of machine-cut spur gears. The powdered coal as it is delivered from the mills is elevated to two mild steel storage bins, one of which is used for feeding to the coal firing pipe, while the other provides storage for week-ends, etc. The primary air is provided by a high-pressure fan, and the air pressure conveys the fuel through a long telescopic pipe protruding well into the kiln and past the cooler portion. Both coal bins are provided with extracting screws with variable-speed drives capable of adjustment by the kiln burner. Fig. 5 is a view of the coal mill house with coal-firing equipment for the kiln.

The clinker as it issues from the kiln is conveyed and elevated to large clinker silos above the cement grinding mill. Gypsum is also handled in a similar manner, for which a separate silo compartment is arranged. Both clinker and gypsum silo outlets are fitted with automatic table feeders which discharge into the feed-drum of the clinker grinding mill. This mill is a " Stag " combination tube mill 6 ft. diameter by 32 ft. 6 in. long, driven in a similar manner to the coal mill by a slow-running motor of 350 h.p. direct-coupled to the mill shaft. A special feature in the design of the plant is that both the grinding-mill motors are arranged in a room partitioned off from the mills so that they are free from dust. Fig. 6 is a view of this motor room, which also houses the transformers and electrical switchgear.

From the cement mill the finished cement is conveyed to two large concrete silos, illustrated in Fig. 2, with railway loading docks on both sides and one end reserved for loading the sacks into road vehicles, of which five can be loaded at one time. Incidentally it is interesting to note that all the works sidings are laid on a gradient so that no shunting in the yard is necessary, and as the Great Western Railway is alongside the works this forms a very cheap and convenient method of dealing with the railway traffic. The Company produces a rapid-hardening cement known as " Chinnorcrete," and the following

particulars are taken from test certificates issued by Mr. R. H. Harry Stanger, dated December 17th, 1928, and March 1st, 1929:

Fineness.

Residue on 76 × 76 mesh sieve ... ... 0·2%

Residue on 180 × 180 mesh sieve ... ... 1·6%

Setting Time.

Initial... 1 hour 15 minutes

Final ... 2 hours 10 minutes

Gauged with 22% water.

Soundness.

Le Chatelier Test.

Expansion after 24 hours ... ... 1·0 m.m.

TENSILE STRENGTH.

Size of Briquettes 1″ × 1″.

Neat Cem'nt	Standard Sand : Cement 3 : 1.								
Days	Days								3
7	1	2	3	4	5	6	7	28	mths
	Pounds per square inch.								
960	500	600	650	670	690	710	730	780	810
950	490	590	650	660	670	700	720	760	800
940	490	590	640	660	670	700	720	760	800
920	480	580	630	660	670	690	710	750	790
910	470	570	630	640	660	690	700	750	790
900	460	560	620	640	660	660	700	740	760
930	482	582	637	655	670	692	713	757	792
Gaug'd with 22% water.	Gauged with 8% water.								

The cement plant is driven electrically throughout, the current being supplied from the Borough of Aylesbury Electricity Works, eleven miles distant, through duplicate overhead lines. Power is received at 10,250 volts, and the Works

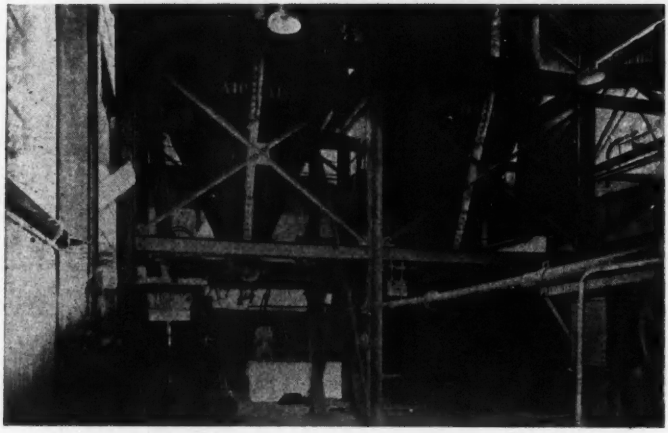


Fig. 5.—Coal Mill House.

are fed through a Ferranti transformer, 865 K.V.A., giving a 400-volt, 3-phase, 4-wire supply for power and lighting, provision being made for an additional transformer to be supplied at an early date. An auxiliary low-tension supply will shortly be provided, and arrangements will be made so that when the main plant is shut down the lighting and workshop motors can be run from the auxiliary supply. The power transformer feeds a Switchgear and Cowans cubicle-type switchboard from which it is distributed by the same make of industrial draw-out type switchgear to the motors and lighting of the works.

The complete electrical installation of the works has been carried out by the Lancashire Dynamo & Motor Co., using their " Maxtorq " induction motors and " Lancashire " self-starting and self-synchronising motors for the specially

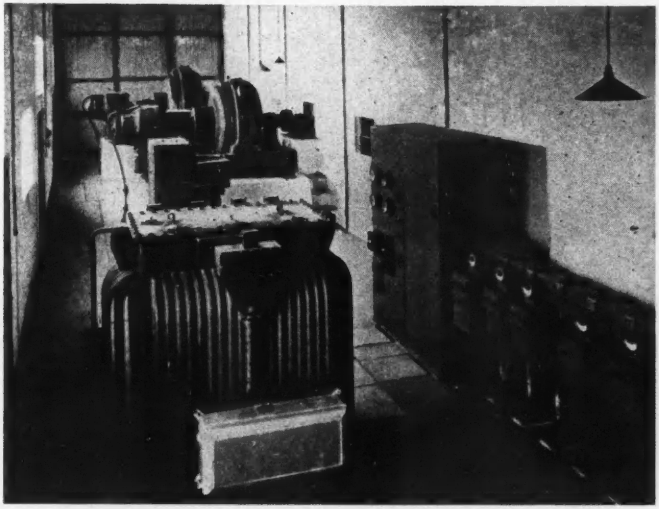


Fig. 6.—Motor, Transformer, and Switchgear Room.

heavy low-speed drives. The 350-B.H.P. 187.5-R.P.M. self-starting synchronous motor driving the cement tube mill, and the 200-B.H.P. 187.5-R.P.M. self-starting synchronous motor driving the coal tube-mill, are each designed to start up against twice full-load torque four times per hour, and are operated by Brookhirst starting panels having a single ratchet handle, a regulator handle arranged for locking in one position, and " stop " push buttons. The entire operation of starting up one of these motors, including self-synchronisation, is therefore carried out by operating one simple ratchet handle. Each of these motors drives through a flexible coupling and straight-tooth gearing on the mill. They are capable of running at a leading power factor of 0.85, which allows of the power factor of the whole installation being brought up to unity at full load.

The synchronous motors are started up like ordinary slip-ring induction motors by means of starters in the rotor circuits. When the motor approaches synchronous speed the exciters coupled to the motors build up their voltage, and the motors pull into synchronism and continue to run as synchronous motors. They have large overload capacity as synchronous machines, and under normal running conditions will not fall out of step even with a considerable amount of overload; should any abnormal load be imposed sufficient to force the motors out of step they continue to run as induction motors until the load falls and then the motors pull into step and again run as synchronous machines.

A 125-B.H.P. 485-R.P.M. "Maxtorq" motor drives the washmill, separators, and slurry elevator, and is designed to start up against twice full-load torque; it is controlled by a Brookhirst auto-transformer type starter. All the motors for driving elevators, pumps, fans, etc., are of the "Maxtorq" single-speed type controlled by star-delta starters.

The majority of the leads are paper-insulated lead-covered and armoured cable, and precautions have been taken to prevent the cable being exposed to any excessive temperatures in the vicinity of the rotary kiln and hot-clinker elevators, etc. Triple earths are provided and arranged so that tests of their efficiency can be carried out. Fool-proof interlocks and indicators have been provided where necessary.

Italian Cement Statistics.

Data secured by the National Fascist Federation of the Cement, Lime and Plaster Industries relating to manufacturers affiliated to that Federation show that in 1926 there was 148 cement factories operated by 104 companies using 760 vertical kilns and 40 rotary kilns. The output in 1928 was estimated at four million metric tons, of which 2,200,000 tons were natural cements and 1,800,000 tons artificial cements. The manufacturers of cement in northern Italy have formed themselves into a cartel with its head office in Milan, and production is regulated by agreement for three years.

Austrian Developments.

The Bauxite Trust (Totis) has, it is stated, approached the Jugo-Slavian controlled cement company of Lietavska-Lucka-Ladce with a proposal to erect an aluminous cement plant with a capacity of 60,000 to 80,000 tons per annum.

The A.-G. fur Zement und Zement Waren is understood to be issuing a share capital of 8 million Kronen with a view to doubling its producing capacity during the present year.

Cement Plant Extensions in France.

The Compagnie Nouvelle des Ciments Portland du Boulonnais is issuing a further Frs. 10,000,000 (£80,000) of capital. The company last year took over the S.A. des Ciments Portland Artificiels de Frangey, and is proposing to develop this plant by increasing its output from 35,000 to 60,000 tons a year.

Raw Material Preparation for Portland Cement Manufacture.

By A. C. DAVIS.

(*Works Managing Director, Associated Portland Cement Manufacturers, Ltd.*)

Wet and Dry Processes.

(*Continued.*)

THERE are two processes for the preparation of the raw materials for the manufacture of Portland cement, namely, the " wet " and the " dry " processes. In the former process the materials are broken down and mixed together in their natural state with the addition of water; in the latter they are roughly crushed, dried if necessary, ground, and mixed in the form of a dry powder.

The opinion is held by some manufacturers that the day of the dry process is passing very rapidly, and plants operating on the process of dry grinding and mixing the raw materials are being converted to the wet process of adding water to the raw materials when grinding and mixing together, on the ground that the better control of the raw mix and resulting higher quality from wet process mixing justify any slight increase in fuel costs. Broadly speaking, however, the decision as to the adoption of the wet or dry process is an individual problem for each plant, the choice depending very largely upon the character of the raw materials to be dealt with and the price of fuel (*i.e.*, relative economy). A discussion of the economics of the matter may therefore be of advantage.

Certain materials in their natural state obviously lend themselves more readily to one method of preparation than to the other. Chalk or marl, by reason of their softness and normally moist condition, almost compel the use of the wet process, particularly where the chalk contains flints; whereas, other things being equal, hard dry limestones and similar materials appear more suited to the dry process. As has been stated, however, there are advantages to be gained by using the wet process, even for hard dry materials, and it is of importance to decide whether these advantages are sufficient to outweigh the disadvantages. Therefore, it may be well to outline some of the considerations affecting a decision in the case of a plant having limestone and shale as its raw materials. It will be understood of course that in both alternatives the production of a cement of the highest quality is assumed, and that the ease of mixing the raw materials, which is one of the advantages of the wet process, has to be balanced by suitable methods on the dry process.

In a plant recently erected, where high cost of fuel and shortage of water made the dry process imperative, very elaborate arrangements for mixing and blending the raw materials were installed. As this comprises one of the most modern attempts to equal the completeness and accuracy of mixing obtained by the wet process, and is claimed to be successful, it may help to an understanding of the problems involved if a description of this plant is included here.

In the quarry there are four ledges of high-lime stone, with ledges of low-lime shales between. At present two ledges are quarried for the former, and

on a third the low shale is obtained. The quarry equipment consists of two well drills, one steam shovel on caterpillars, and one electrically-driven shovel. The material is loaded into 11-yd. quarry cars, which are hauled to the crusher by steam locomotives.

The crushing plant is equipped with a roll crusher, 36 in. by 60 in., driven by a 150-h.p. motor. The crushed shale is elevated from the crusher to a storage bin by a 42-in. inclined-pan elevator, driven by a 50-h.p. motor. The material is fed from this bin by an apron-feeder to a grinding mill, driven by a 250-h.p. motor; the bin provides a continuous feed to the mill, and stores the heavy intermittent charges of rock delivered to it by the crusher.

The mill product is elevated and conveyed to eight 25-ft. by 65-ft. rock storage tanks, from which the mix is made. This product is sampled en route to storage and passes over an automatic weigher, so that both the quantity and the composition of rock in each storage tank are accurately determined.

The mix is then made by drawing off from the rock storage the proposed mixture of shales by the aid of poidometers and cradle feeders. At least three grades of shale are used, and they are fairly well mixed in the drag and elevator before they enter the driers. This mix is checked and corrections are made as found necessary.

The material in subsequently passing through the driers and grinding mills is further mixed, although it can, and does, contain a plus or minus error at this point. A pump transport system operated by time-clock distributes the raw material from the mills to four correction silos changing from one to another at frequent intervals. The four correction silos are 25 ft. in diameter and 65 ft. high, with a capacity of 970 tons each, a total of 3,880 tons. Underneath them are four 6-in. pumps operating simultaneously delivering the kiln feed to the kiln-feed bins. The level in these bins is maintained by bin-level signals which operate the valves in the transport line. When the kiln-feed bins are full the valves automatically close, permitting the material to discharge back into the correction silos. This material is then fed to one bin after another in rotation with the mill stream.

It is stated that there is no tendency for the materials to separate or to classify according to weight or fineness during transportation, and that a series of thin layers is built up which will run together during their withdrawal from storage. These thin layers are composed of three constantly-rotating streams, and this constant mixing should level out any errors in the original mix. The mathematical possibilities of this system are most interesting to calculate, but it is claimed that in practice in proper operation by this method the kiln-feed error is reduced to a factor comparable with the best possible in the wet process.

A comparison of this elaborate system with that necessary when the wet process is adopted is given in Figs. 1 and 2 and shows that up to this point the wet process offers advantages in less capital expenditure and ease of control. This will be referred to later when explaining the relative power consumption of the two systems.

Turning now to the comparative economics of the burning operation, it is proposed to compare the alternatives in dealing with limestone containing, say,

95 per cent. of calcium carbonate and with a moisture content of 1½ per cent., and shale or clay containing 10 per cent. of moisture, these figures representing materials very commonly used.

Wet Process.—On the wet process it will be assumed:—

(*a*) That the slurry contains 40 per cent. of water.

(*b*) That, by efficient means of drying the slurry, the gases escaping from the kiln have a temperature of about 450 deg. F.

(*c*) That clinker leaves the cooler at from 200 deg. F. to 300 deg. F.

Under these circumstances the consumption of standard coal (having 12,600 B.th.u's per lb.) will be in the neighbourhood of 24 per cent. per ton of clinker

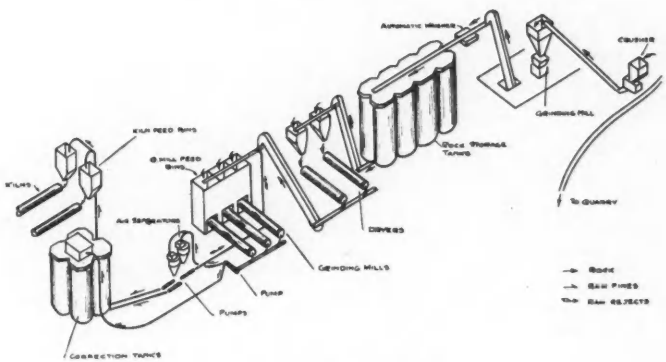


Fig. 1.—Dry Process.

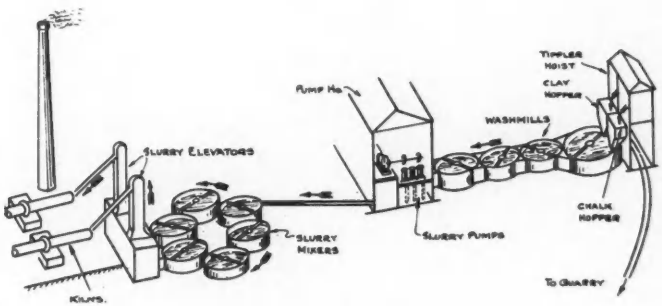


Fig. 2.—Wet Process.

produced, but such a low chimney temperature presumes the utilisation of the maximum heat contained in the gases for its legitimate purpose in the kiln and leaves no surplus for a waste-heat boiler. Therefore power to run the works must be generated separately.

The quantity of fuel which will be consumed for power purposes depends upon the efficiency of the works (particularly of the grinding plant), the fineness of grinding, the steam consumption of the prime mover, and so on. A sufficient figure would probably be about 12 per cent. of fuel per ton of cement produced, and for the present purpose that figure will be taken. Thus the total fuel consumption throughout the wet-process works, including burning and power, will amount to something in the neighbourhood of 36 per cent. of standard coal per ton of cement.

Dry Process.—In the dry-process works it will be assumed:—

(*a*) That the raw meal entering the kiln will be damped to the extent of about 7½ per cent. of water.

(*b*) That the escaping gases will have a temperature of about 1,450 deg. F.

(*c*) That the clinker leaves the cooler at the same temperature as in the wet process, *i.e.*, between 200 deg. F. and 300 deg. F.

The consumption of standard coal per ton of clinker should thus be from 20 to 21 per cent. or, say, 20.5 per cent. A further, say, 1.25 per cent. of fuel for drying the raw materials must be added to obtain the overall fuel consumption, making 21.75 per cent. per ton of clinker for all purposes.

With this coal consumption there will probably be sufficient heat in the escaping gases to generate steam in a waste-heat boiler for the power required to run the plant, and it will be assumed that a waste-heat boiler is attached to the dry kiln. Therefore, theoretically the total fuel consumption for drying the raw materials, burning, and power purposes would be 21.75 per cent., which is 14.25 per cent. better than the wet-process plant. With coal costing, say, 18s. per ton this represents a saving of 2s. 6¾d. per ton of cement. In actual working, however, a certain amount of power fuel would have to be used for starting up and providing for irregularities in running as between the kiln and the rest of the plant. If this is assumed to be 1½ per cent. per ton of clinker it represents a charge of 3¼d. per ton.

Then, again, a waste-heat boiler for a one-kiln plant would probably cost about £3,000 more than a similar one for direct firing, and an allowance of 1¼d. per ton must be made for this additional capital charge to provide for interest and depreciation. If allowance is made also for the additional fan-power required, likely to be about 4½ per cent. of the total power required (or 1¾d. per ton) a reduction of 6d. has to be made from the 2s. 6¾d., leaving a net saving of 2s. 0¾d. per ton, or an annual saving of about £8,000 with a plant of a capacity of, say, 1,600 tons per week, subject to any saving in reduced power

consumption for wet grinding and any increased cost for extra capital required in dry grinding and mixing plant.

The heat distribution in the two kilns would be approximately as follows:

	WET PROCESS		DRY PROCESS	
	Tons of coal per 100 tons of clinker.	Proportion of total coal.	Tons of coal per 100 tons of clinker.	Proportion of total coal.
		per cent.		per cent.
Reactions	6.0	25	6.0	29¼
Water evaporation, superheating, etc.	10.4	43½	1.0	5
Heat in flue gases from combustion gases and CO_2	3.6	15	9.8	48
Heat lost in radiation	3.0	12½	2.8	13½
Heat lost in clinker and not accounted for	1.0	4	0.9	4¼
TOTAL	24.0	100	20.5	100

This is approximately a distribution which might reasonably be expected in two kilns, one wet and the other dry, using identical limestone and clay and producing the same output of clinker per hour under the assumed conditions already stated.

It will be noted that the distribution of heat differs in the important respect that the heat required for water evaporation and superheating in the wet kiln is much greater, while that available for use in a waste-heat boiler is much less, as the useful heat in the escaping gases is reduced to the economic limit in the wet kiln by efficient operation. In the dry kiln the percentage of heat required for water evaporation is small, and the surplus heat contained in the flue gases is made to do useful work in a waste-heat boiler as an alternative to wasting it. Water evaporation on the dry plant requires about 1 per cent. of coal per ton of clinker, while the heat available in the flue gases is equivalent to about 10 per cent. of coal, as against 10½ per cent. and 3½ per cent. respectively in the wet kiln. The amount of heat required for the chemical reactions must be the same in both cases, although the percentage of the total heat used for this purpose is greater in the dry kiln.

The wet kiln is probably as efficient a method of burning as can be expected under present conditions. It has to deal with a large quantity of water contained in the slurry, and the temperatures of both the escaping gases and of the clinker leaving the kiln are low. The efficiency of the dry kiln, however, must be computed after considering the waste-heat boiler and kiln as a single unit. About two-thirds of the heat in the kiln gases can be used to produce steam

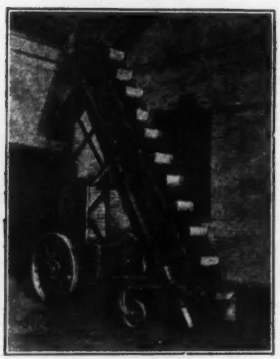
in the boiler, after allowing for radiation losses in the boiler system and maintenance of the necessary draught, provided proper precautions are taken to prevent infiltration of cold air and so forth. Therefore, in addition to 29¼ per cent. of the total coal used for chemical reactions in the kiln, more than 31 per cent. must be added for the work done by the flue gases, making a total of about 60 per cent. for the overall efficiency of the kiln and boiler, against only 25 per cent. for the wet kiln.

In both kilns a certain temperature must be maintained in the firing zone to complete the calcination of the raw materials and to effect clinkering, and therefore a certain minimum number of British thermal units are required in both cases. When the work of calcination and clinkering is completed the gases retain a similar and considerable quantity of heat. In the wet kiln this heat is utilised to dry out the slurry, while this function is practically unnecessary in the dry kiln and the heat can be used in this case for power purposes.

In considering the problem as a whole, however, we cannot confine ourselves to the limits, however important, of kiln efficiency and coal consumption. It has already been said that in the operations preceding the burning for equal quality the advantage lies with the wet process in several important respects,

(*Continued on page* 185.)

"B.B." ELEVATORS



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COMPLETE ELEVATING AND CONVEYING PLANTS.

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DUNSTABLE. & Co., Ltd.

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such as less capital expenditure, ease of grinding and mixing, lower power consumption, freedom from dust, and so on.

It has sometimes been stated that more power is required for manufacturing purposes on the wet process than on the dry, but experience indicates that the reverse is the case. The wet process appears to be more economical in this respect if the elaborate arrangements which are necessary to secure a thorough mixing of dry materials, and which were described earlier, are adopted; and this is essential if a high quality cement is to be produced.

The actual experience in the case of three plants which have been converted from the dry to the wet process may perhaps be quoted:

Plant No. 1.—Using a hard limestone with a small amount of plastic clay mixed in. Consumed 22 K.W.H. per barrel grinding dry to a fineness of 85 through 100-mesh sieve. Wet process reduced power to 18/19 K.W.H. per barrel.

Plant No. 2.—Soft limestone. Power reduced from 21½ K.W.H. on the dry process to 18 K.W.H. per barrel on the wet, with improved fineness.

Plant No. 3.—Using an extremely flinty and hard limestone, consumed on the dry process about 21½ K.W.H. per barrel. Now using on the wet process about the same power, but the fineness of the raw material has been increased

(*Continued on page* 186.)

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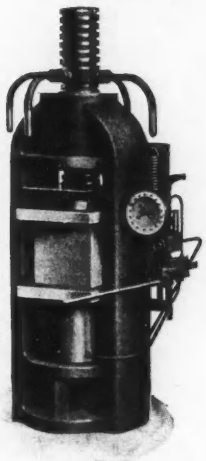

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from 80 per cent. to 92 per cent. through a 100-mesh sieve, with resulting improvement in the quality of the cement. Saving in power was thus used for improved quality.

It is the opinion of some manufacturers who have experience of operating both processes on the same raw materials that the power saving on the wet process is 10 to 20 per cent. over the dry process for an equal quality of cement in both cases. This opinion is more or less confirmed by the experience of some Canadian cement works which have just changed over from the dry to the wet process, the actual power used on the wet process in this case being 14.7 per cent. less than the average power used previously for the same grinding on dry process. In this case also it is stated that there is considerable saving in the power required for clinker grinding, which is attributed partly to the physical nature of the clinker from the wet kilns. As a partial offset to the saving in power, however, it is stated that the consumption of grinding bodies is much greater in wet grinding than in dry grinding, the increase in the consumption of metal grinding bodies often being more than 100 per cent. on the wet process.

(To be continued.)

Imports of Cement into Philippine Islands.

By a law of December 8, 1928, the importation of cement into the Philippine Islands is limited in that cement may be imported only if meeting the demands of Circular No. 33 of the Bureau of Standards of the U.S. Department of Commerce and Labour. The measure does not apply to cement made in the United States.

INDEX TO ADVERTISERS.

Adie, Patrick	—	Fuller Company	vi
Allen, Edgar, & Co., Ltd.	—	Glover, W. T., & Co., Ltd.	—
Alley & Maclellan, Ltd.	ix	Helipebs, Ltd.	ix
Amsler, Alfred J., & Co.	185	Henry, A. S., & Co., Ltd.	—
Avery, W. & T., Ltd.	—	Howard, J. & F., Ltd.	—
Babcock & Wilcox, Ltd.	viii	Howden, T. C., & Co.	185
Bagshawe & Co., Ltd.	184	International Combustion, Ltd.	vii
Bailey, Sir W. H., & Co., Ltd.	xiv	Judd, Budd, Ltd.	—
British Jeffrey-Diamond, Ltd.	—	Locker, Thos., & Co., Ltd.	xii
British Rema Manufacturing Co., Ltd.	iv	Low & Bonar, Ltd.	—
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Constantin, E.	vi	Newell, Ernest, & Co., Ltd.	i
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Curtis, A. L.	—	Polysius, G.	iii
Davidson & Co., Ltd.	xiv	Ruston & Hornsby, Ltd.	xiii
Davison, Charles, & Co., Ltd.	—	Schmitt, F. E.	iii
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Fellner & Ziegler	xv	Vickers-Armstrong, Ltd.	x & xi
		Wellman Bibby Co., Ltd.	—

(*CLASSIFIED INDEX ON PAGE II*).